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Thick-liquid chamber protection for large beam arrays

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Recent research advances have improved the ability to create and control complex liquid structures for heavy-ion fusion chambers, including oscillating jets, smooth cylindrical jets, and wall-confined vortex flows. These structures can be used to assemble liquid configurations that completely shield all chamber structures from direct exposure to heavy-ion fusion (HIF) target x rays and neutrons. Experiments and theory now indicate that liquid geometries can be controlled with sufficient precision to allow large beam arrays, with recent designs investigating two-sided target illumination with 11x11 beam arrays.

The phenomena which must be understood and controlled in HIF chambers are driven by the major functional requirements, including the rapid regeneration of conditions appropriate for target injection, beam focusing, and target ignition and gain; control and recovery of fusion energy released by targets; the protection of chamber structures and final-focus elements from neutron, x-ray, debris and mechanical damage; and the recovery of tritium and target debris.

This talk overviews the major phenomena which govern chamber response and operation, and the current status of research on the major phenomena. This portion includes discussion of liquid hydraulics including thick liquid pocket generation and disruption phenomena, ablation and target debris venting and condensation, and materials equations of state including the recent identification of ternary salt (flinabe) which allows very low (10^9 molecules/cm^3) gas pressures to be generated in the final-focus magnet region.

The talk then discusses current conceptual designs for thick-liquid chambers, including a point design for two-sided illumination with 11x11 beam arrays. Optimum beam arrangements are discussed, including configurations that permit illumination of the target inside a conical annulus by deleting some corner and center beams from the square array lattice. A particular focus of this discussion is on the arrangement of liquid shielding materials, the control of the gas density along the beam path, and approaches to introducing plasmas for beam neutralization along the beam path. Areas for future research are then discussed.